SUBSURFACE BARRIER VERIFICATION WITH THE SEAtrace™ MONITORING SYSTEM

TECHNOLOGY NEED

Subsurface barrier materials and emplacement methods are being developed to prevent the spread of contaminants from hazardous waste sites. Many of these new applications involve barrier structure emplacement above the water table. For instance, barriers are placed beneath underground storage tanks to prevent mobilization of contaminants during tank remediation. Site Technology Coordination Group needs are identified as:

SR-3014 Performance monitoring systems for *in situ* stabilization and barrier technologies using non-intrusive technologies to monitor subsurface contamination, contaminant fate, and transport after remedial activities.

RL-WT031 Surface barriers are being used at many Hanford environmental restoration and waste management sites and more barriers are expected in the future. Since the design life of the barrier is 1,000 years, data are needed on barrier degradation to better understand the validity of the design-life estimate.

OR-BW-08 Ensure that performance can be reliably determined and monitored for periods long enough to achieve objectives (e.g., ranging from decades to centuries). Related needs include keeping up with advances in grouting/barrier technology, understanding the interactions of grouts/barriers with wastes/media, and measuring long-term barrier performance (e.g., stability and longevity).

Conventional hydrologic testing methods that have historically been applied to structures below the water table cannot be applied to barriers in the unsaturated zone. Geophysical techniques, such as ground penetrating radar, electrical resistance tomography, and seismic surveys are useful for site characterization and general barrier configuration visualization. However, these techniques have not demonstrated sufficient spatial resolution to quantify the barrier construction flaws of interest.

TECHNOLOGY DESCRIPTION

SEAtrace™ is a gaseous tracer-based subsurface barrier verification system developed for use on containment barrier structures located above the water table. Non-hazardous tracer gas is injected inside the barrier, and gas sampling points are located outside of the barrier to detect the arrival of the tracer gas through breaches in the barrier structure. SEAtrace™ integrates real-time soil-gas sample collection and analysis with a global optimization technique to locate and size flaws in barriers in real time. The system is self powered (solar panels with battery backup), thermally controlled, remotely accessible through a cellular modem link, and meant to operate for months at a time without onsite user intervention.

BENEFITS

The SEAtrace™ barrier monitoring system is an enabling technology that provides quantitative barrier verification for installations above the water table where no capability currently exists:

- The approach is conservative in that it measures vapor leaks in a containment system where the greatest risks are posed by liquid leaks.
- SEAtrace™ provides a degree of resolution in both leak size and location that is unattainable with geophysical techniques.
- It is applicable to any impermeable barrier emplacement technology in the unsaturated zone. It uses readily available non-hazardous gaseous tracers.
- Direct-push techniques avoid excessive drilling costs and secondary waste generation.
- SEAtrace™ can emplace vapor injection and sampling points.
- The soil-gas monitoring system provides continuous and unattended contaminant plume measurements for remote site operation.

- In addition to assessing initial barrier integrity, the system can also provide long-term monitoring of contaminant soil gases for surveillance of the containment system's performance over time.

CAPABILITIES/LIMITATIONS

SEAtrace™ is applicable to impermeable barrier installations above the water table. The monitoring system is a stand-alone unit, with a cost of approximately $100K. Operation of the monitoring unit, and analysis/interpretation of the data, requires specialized skills and an understanding of vapor phase transport in soils. The current system is capable of monitoring up to 64 gas sampling ports in the soil, and the number of ports can be expanded. On very large barriers (acres) it may be necessary to verify the barrier walls in segments to ensure adequate monitoring coverage. The capabilities are summarized as follows:

- Autonomous operation.
- Remote data access.
- Real-time sample collection and analysis.
- Leak assessments completed within 30 minutes of sample analysis.
- Leak characterization capabilities:
  - --Leak size within 0.15-meter diameter.
  - --Location within 0.5 meter.
- Multiple leaks can be detected.
- The system also performs as a long-term monitoring system for contaminants in the vapor phase.

COLLABORATION/TECHNOLOGY TRANSFER

Collaboration with other barrier verification technologies occurred during the 1997 Dover Air Force Base and Brookhaven National Laboratory demonstration projects:

- Hydraulic testing technologies (Westinghouse Savannah River Company).
- Geophysics (Lawrence Berkeley National Laboratory and MSE Technology Applications).
- Liquid tracer testing techniques (Sandia National Laboratories).
- Electrical resistance tomography (Lawrence Livermore National Laboratory).
- Perfluorocarbon gaseous tracer testing (Brookhaven National Laboratory).

This integrated testing program was sponsored by the Subsurface Contaminant Focus Area. In addition, extensive collaboration has occurred over the past 3 years in original proof-of-concept testing and prototype development with Sandia National Laboratories.

The developer, Science and Engineering Associates, Inc.(SEA) is the commercialization entity and is actively marketing the technology. The SEAtrace™ technology is "patent pending" since a patent application was filed on April 15, 1997. SEA has participated in two commercial barrier vendor conferences, a visitors' day at the Dover Air Force Base test site, and a National Academy of Sciences review of barrier verification technologies. SEA is cost sharing the current demonstration phase of the CMST-funded project.

ACCOMPLISHMENTS

In the initial phase of the CMST-CP funded project, a prototype SEAtrace™ system was developed that integrated soil-gas monitoring and leak detection into a stand-alone field system. This work, completed in the fall of 1997, included:

- Development of the stand-alone monitoring system with solar electric power, thermal control, low power control and data acquisition computer and 64-port gas sampling and analysis.
- Development of a generalized data analysis code to allow location and sizing of barrier flaws in three dimensions, with preprocessing optimization to reduce analysis time.
- Design and construction of a barrier mockup facility that allowed controlled opening and closing of "leaks" (various sized gate valves) to test the system.

- Execution of a testing program that demonstrated the system's leak locating capabilities in the barrier mockup facility.
- Demonstration that leaks as small as 1.1 cm in diameter could be detected with the system.

This Phase I work was documented in a topical report.

The products of this development work were applied to two test barriers in a program sponsored by the Subsurface Contamination Focus Area in the summer and fall of 1997. The first field test on a test barrier occurred at the Dover Air Force Base Groundwater Remediation Field Laboratory. During the course of this testing program, the system evaluated two test barrier cells and two engineered leaks. The test results indicated that the inversion code's ability to locate flaws in the barrier is good, locating the two-engineered flaws within 0.3 to 0.6 m from their actual location in space. The code predicted the size of the flaws within a factor of 2 to 3 for these two known leaks. Six unanticipated flaws in the two test cell barrier panels were detected.

The second evaluation of a test barrier installation occurred at the Brookhaven National Laboratory where colloidal silica, permeation-grouted barrier was installed. The SEAtrace™ system located ten leaks in this viscous liquid barrier. Ten leaks were denoted. The barrier wall not extending as close to the surface of the soil as anticipated caused three of the leaks. The rest of the flaws were about equally distributed over the barrier panels and joints. Calculated leak diameters ranged from 8 cm to a meter.

TECHNICAL TASK PLAN (TTP) INFORMATION

TTP No./Title: AC21-96MC33125 - Subsurface Barrier Validation with the SEAtrace™ Monitoring System

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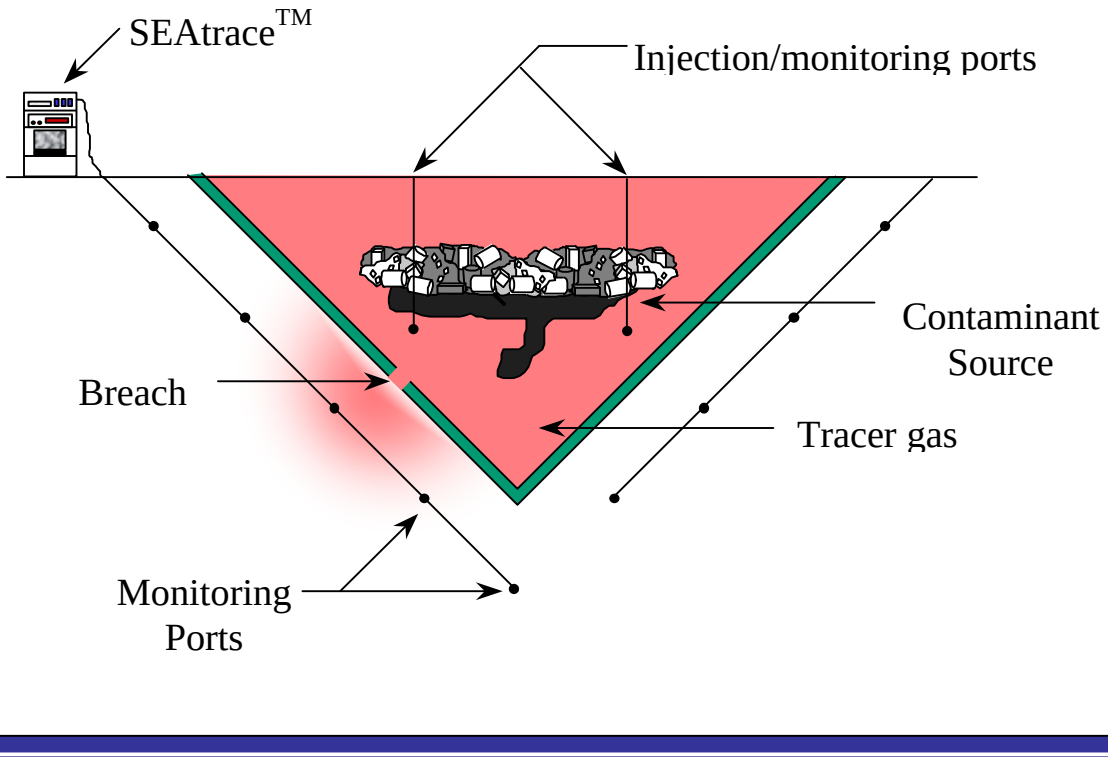
The SEAtrace™ monitoring system is self-powered (solar panels with battery backup), thermally controlled, remotely accessible through a cellular modem link, and was designed to operate for months at a time without onsite user intervention.



A non-hazardous tracer gas is injected inside the barrier, and gas-sampling points are located outside of the barrier to detect the arrival of the tracer gas through breaches in the barrier structure.